

The Skeletal System

Structure and Support

A decorative graphic in the bottom-left corner consisting of three thin, curved lines that sweep upwards and to the right. Each line has a small, solid grey circle at its starting point.

The Skeletal System

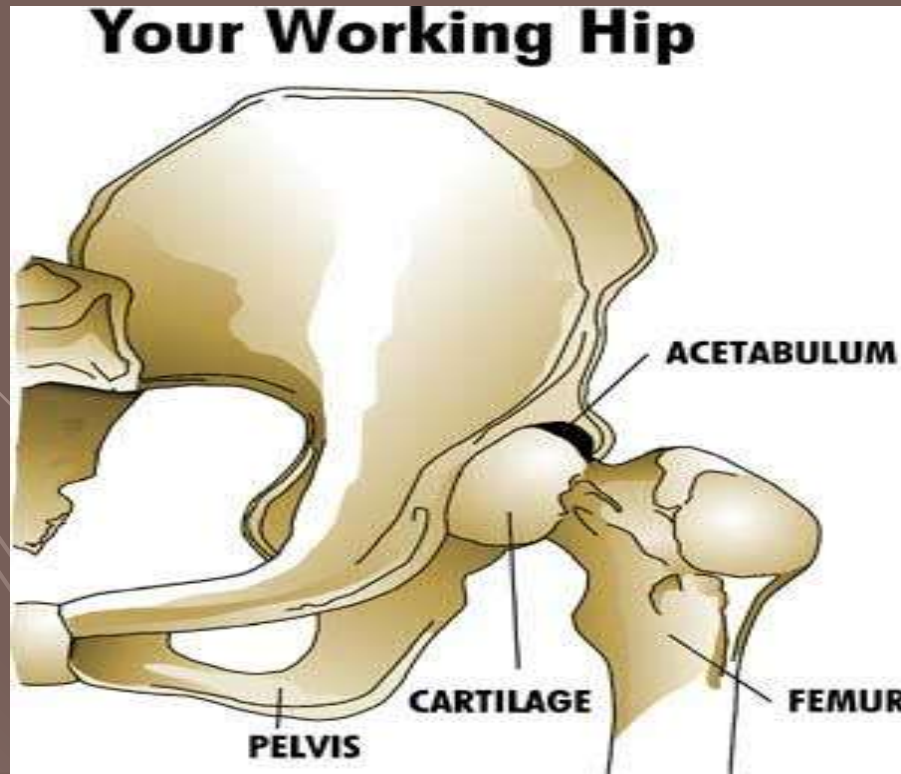
- The organs of the skeletal system are bones and the structures that connect bones: ligaments, tendons and cartilage.



The Skeletal System

Functions of Bone Tissue

- The major function of this system is **support.**



The Skeletal System

Functions of Bone Tissue

- Another major function is **protection** of underlying organs.
- Examples include the skull protecting the brain and the ribs protecting the heart and lungs.



The Skeletal System

Functions of Bone Tissue

- The skeletal system allows the bodies **movement**.
- The skeletal system acts as a base of attachment for the skeletal muscles which give the human body mobility.



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Functions of Bone Tissue

- The bones also function in **mineral homeostasis.**
- The bones store many minerals such as calcium and phosphorus and allow for consistent use and dispersal of these minerals.

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Functions of Bone Tissue

- The bones are also the site of **hematopoiesis.**
- The centers of bones contain marrow which is the site of red blood cell (rbc) production or hematopoiesis.



The Skeletal System

Functions of Bone Tissue

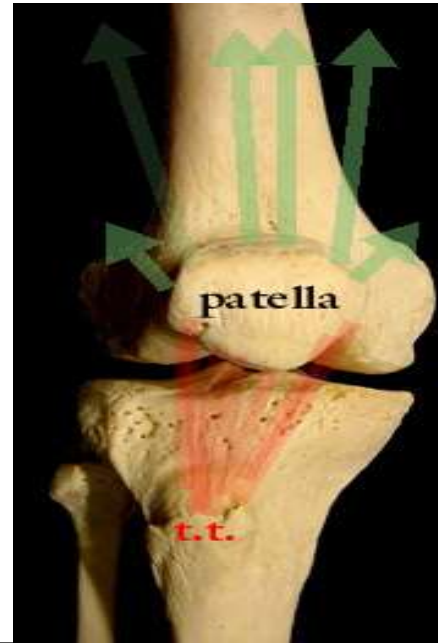
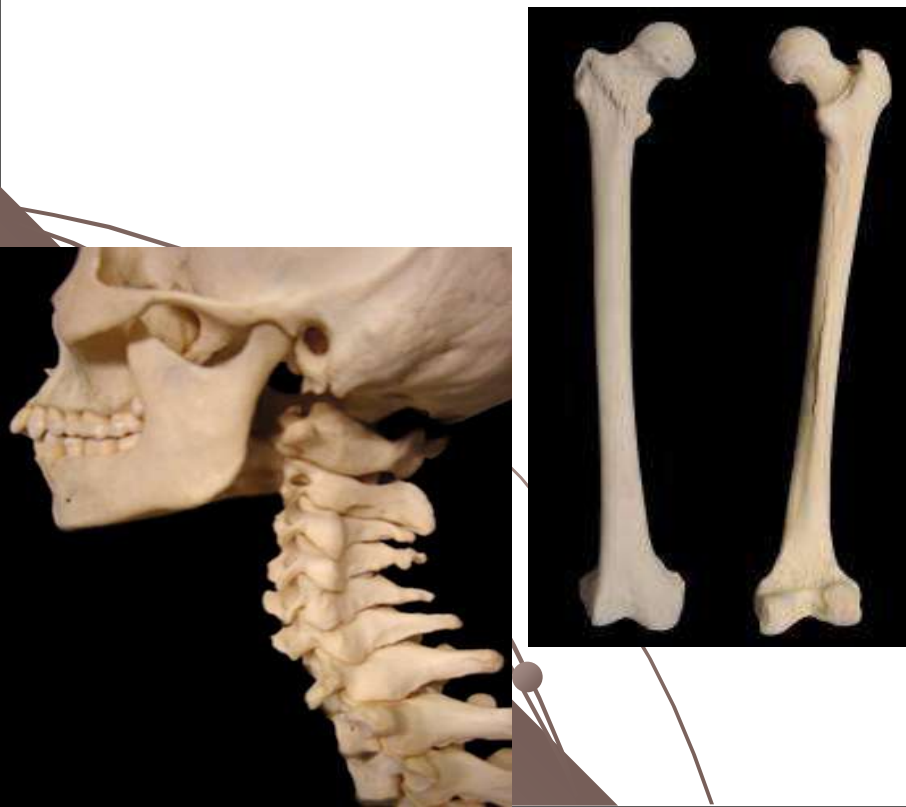
- They also act as **storage** facilities for **energy**.
- The yellow bone marrow of long bones (example: femur) acts as a chemical energy reserve.



The Skeletal System

Classification of Bones

- Bones are classified by their shape.



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Classifications of Bones

- **Long bones** consist of a shaft with two ends.
 - Examples: thigh bone or femur and upper arm bone or the humerus



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Classifications of Bones

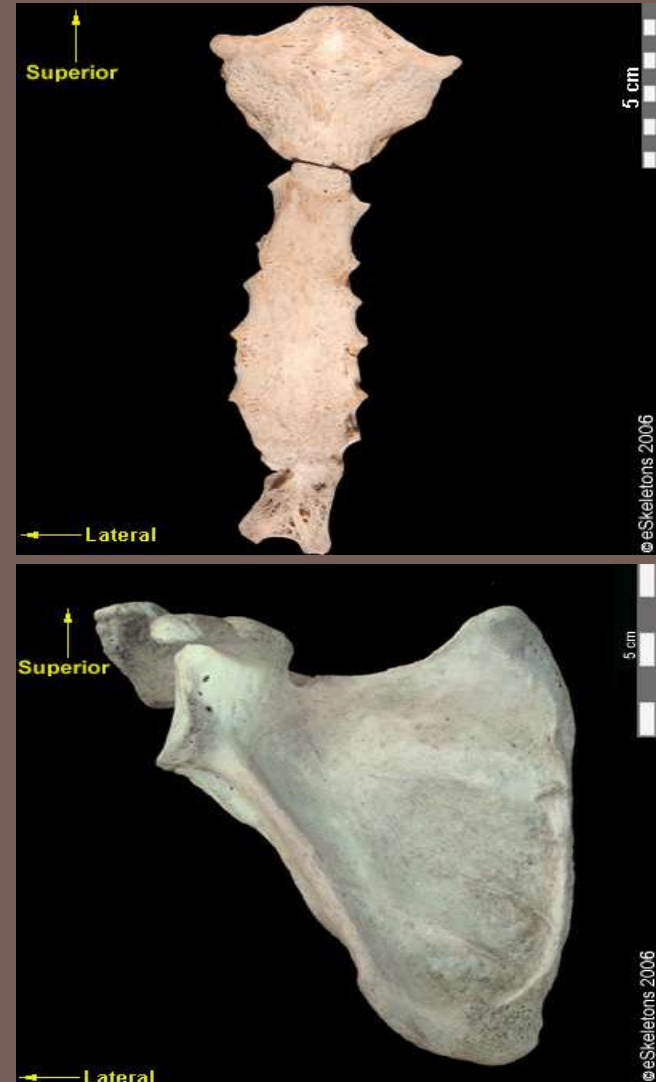
- **Short bones** are cube-like in shape.
 - Examples include wrist bones or carpals and ankle bones or tarsals.



The Skeletal System

Classifications of Bones

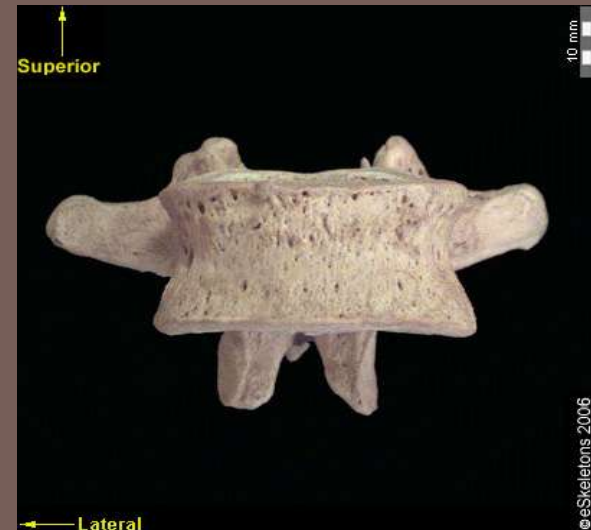
- **Flat bones** are thin and usually curved.
- Examples include the breast bone or sternum and the shoulder blades or scapulae.



The Skeletal System

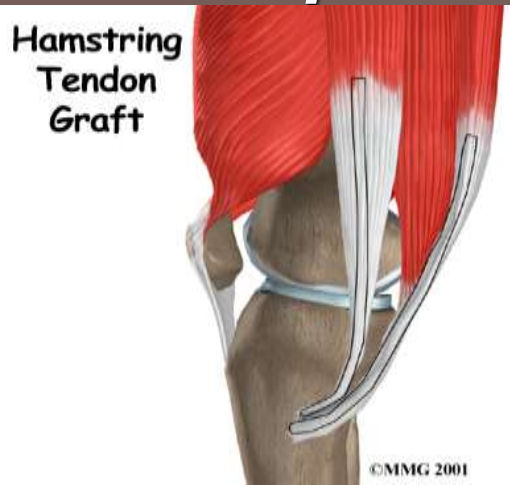
Classifications of Bones

- **Irregular bones** are not long, short or flat bones.
- Examples include the vertebrae.



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- There are **two** other types of bones that are *not* classified by shape:
 - **Sesamoid bones** which are bones that form within a tendon, the only human sesamoid bone is the ***patella*** or knee cap.



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- **Wormian bones** are tiny bones that form in between the major skull bones that form as a result of a disorder.



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Structure of Long Bones

- The shafts of these bones are known as the **diaphysis**, it consists of a central medullary cavity (which is filled yellow marrow) and is surrounded by a thick collar of bone.

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Structure of Long Bones

- The ends of the shaft are known as **epiphyses** (plural) which are primarily made up of spongy bone surrounded by a thin layer of compact bone.
- The remnant of the epiphyseal plate (growth plate) is called the **epiphyseal line** which is bone that has matured from cartilage.

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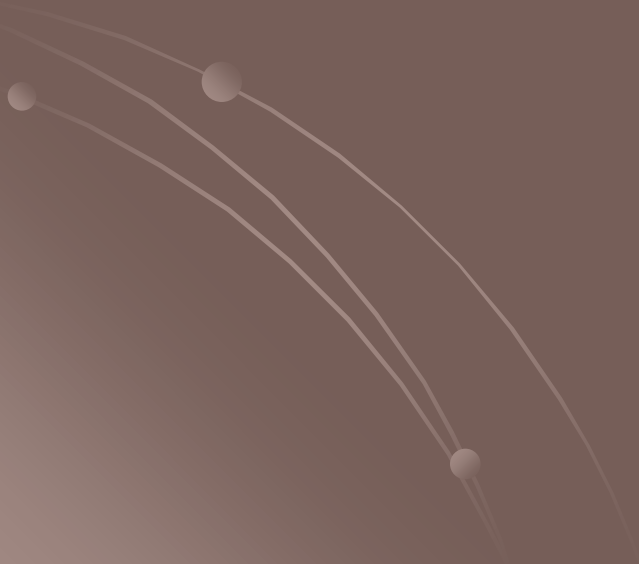
Structure of Long Bones

- The **periosteum** is the outer fibrous covering of the diaphysis which is the site of the osteogenic layer or the bone producing layer.
- The **endosteum** is the inner lining of the medullary cavity.

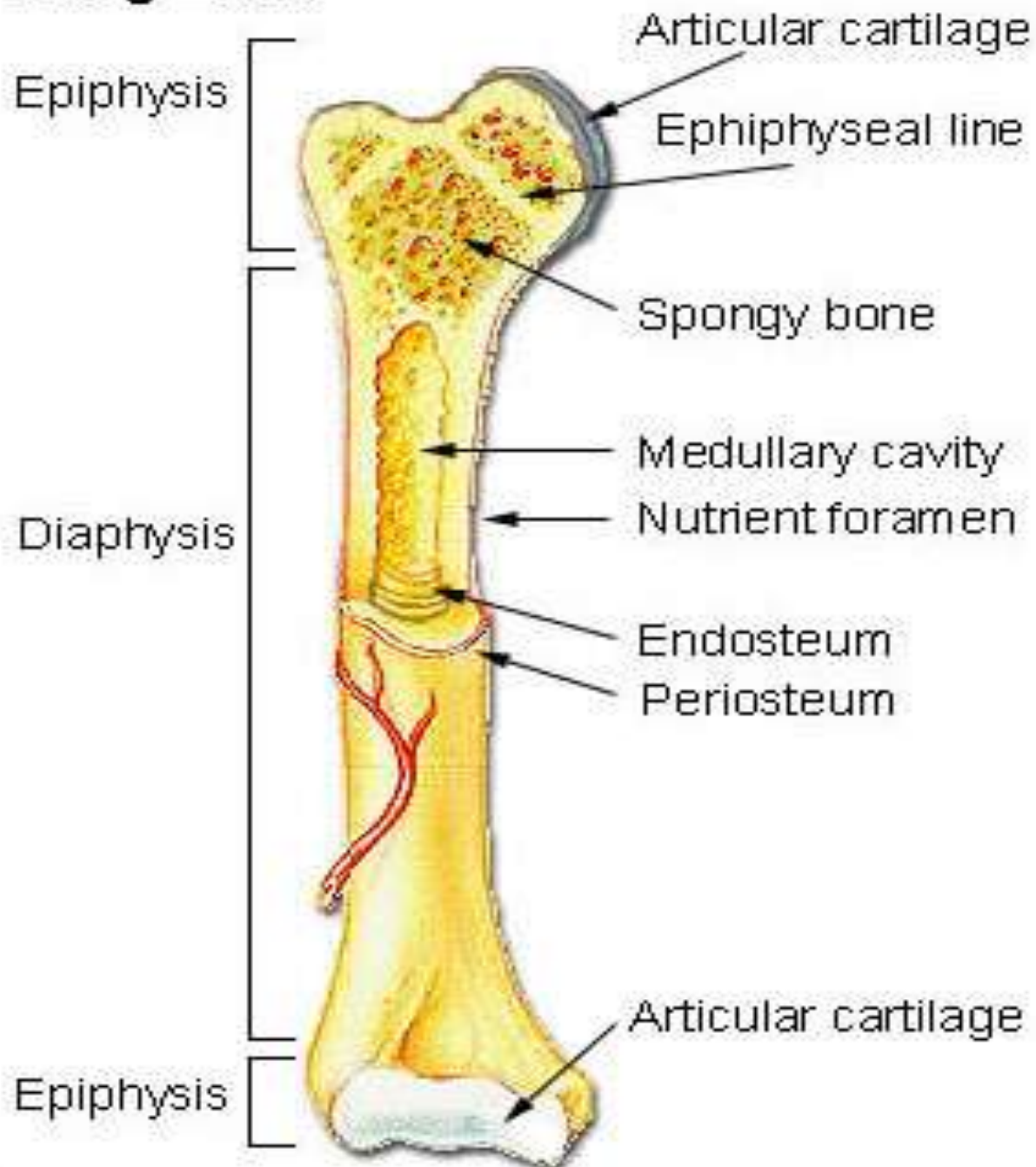
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Structure of Long Bones

- The **articular cartilage** is the pad of cartilage at the epiphysis that acts as a shock absorber for the joints.



Long Bone



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Structure of Flat Bones

- The outer layer is **also** the periosteum.
- The inner layer is **also** the endosteum.
- Flat bones are layered, compact bone then spongy bone and then compact on the opposite surface.

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Histology of Bone

- Chemically bones are both organic and inorganic.
- They are 35% organic and 65% inorganic.

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Histology of Bone (cont)

- The primary inorganic component of bones are mineral salts such as calcium phosphate.



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Histology of Bone (cont)

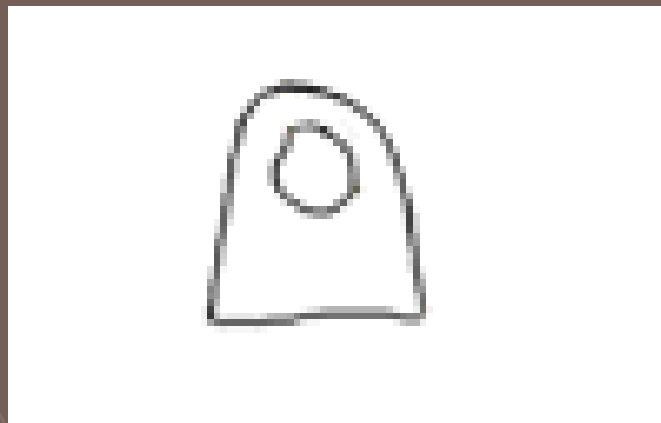
- The organic portion of our bones is found in the form of living cells.
- ***Osteoprogenitor*** cells are the cells bones grow from.



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Histology of Bone (cont)

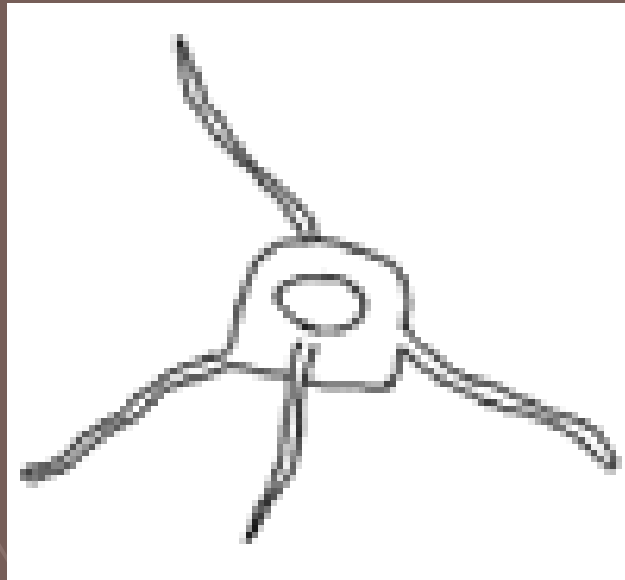
- ***Osteoblasts*** make up the bones matrix.
(Think back to our discussion on tissues!!!)



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Histology of Bone (cont)

- **Osteocytes** are mature bone cells.



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Histology of Bone (cont)

- **Osteoclasts** are responsible for repairing damaged bone.



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Microscopic Anatomy of Bone

- **Compact bone** is solid, dense and smooth.
- The structural unit of *compact bone* is the **Haversian System or Osteon.**

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Microscopic Anatomy of Bone (cont)

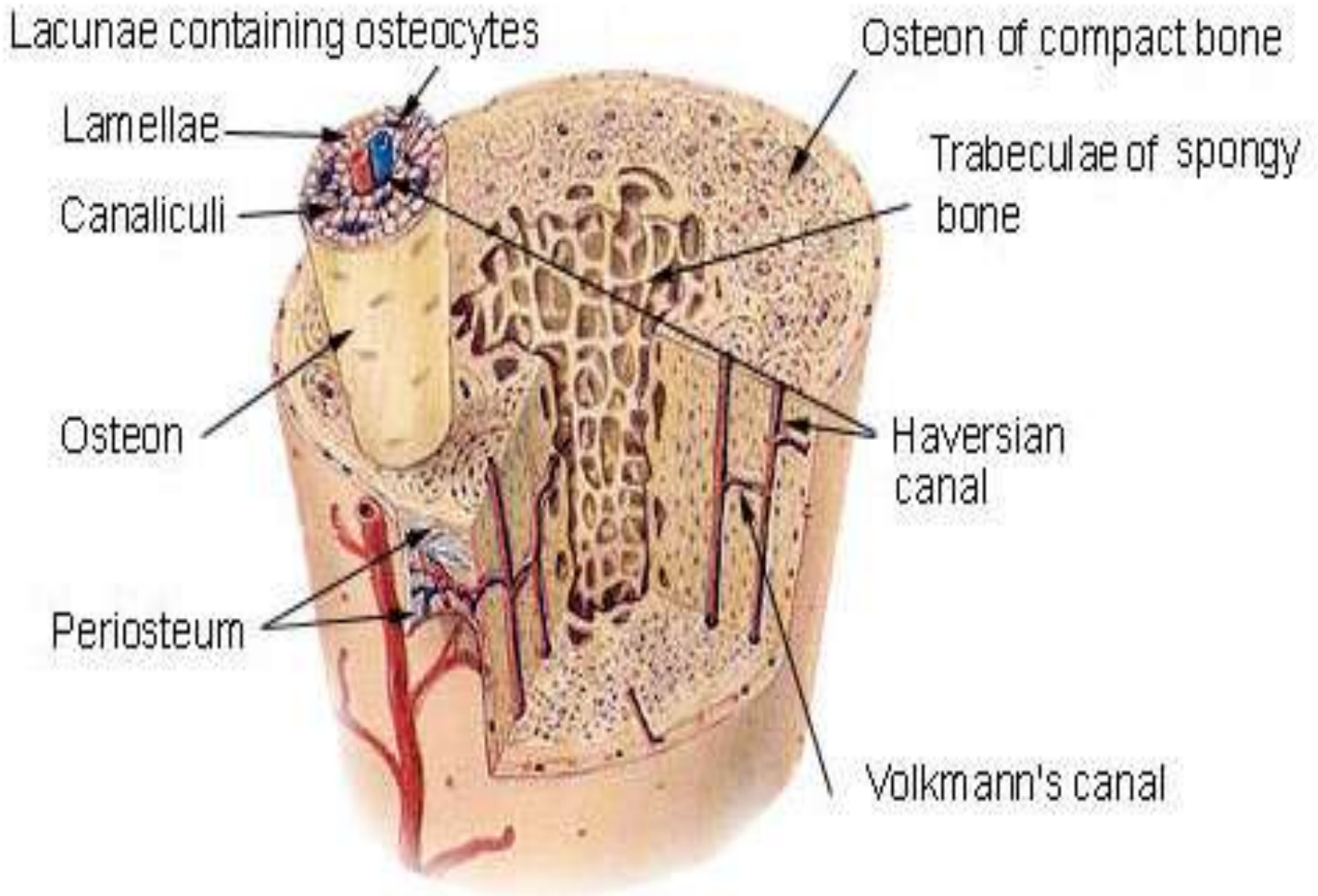
- *Haversian Systems* are made up of elongated cylinders “cemented” together to form the long axis of a bone.
- The cells of the *Haversian System* are **osteocytes** (“spider shaped” bone cells) with in a matrix of collagen and calcium salts, in layers around a central **Haversain Canal** which contains blood vessels and nerves.

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Microscopic Anatomy of Bone (cont)

- **Volkman's canals** connect the blood and nerve supply of adjacent Haversian systems together.
- **Spongy bone** consists of poorly organized *trabeculae* (small needle like pieces of bone) with a lot of open space between them and it is nourished by diffusion from nearby Haversian canals.

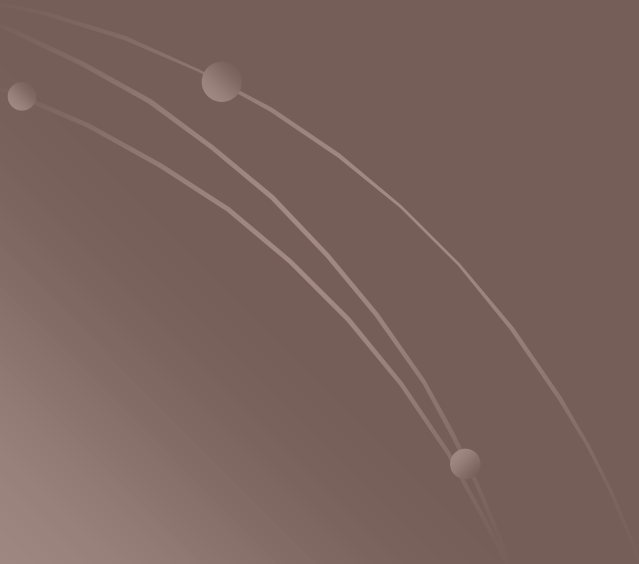
Compact Bone & Spongy (Cancellous Bone)



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Bone Development

- Bone Growth and Development



The Skeletal System

Bone Development (cont)

- The “skeleton” of an embryo is composed of fibrous CT membranes that are loosely shaped like bones.
- This “skeleton” provides supporting structures for bone formation or **ossification**.
- At about 6-7 weeks of gestation, ossification begins and continues throughout adulthood.


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Bone Development (cont)

- Ossification follows one of two patterns:
 - **Intramembranous Ossification** is when a bone forms on or within a fibrous CT membrane, *flat bones* form in this manner.
 - **Endochondral Ossification** occurs when a bone is formed from a hyaline cartilage model (growth plate like development), most bones form in this way.

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The Physiology of Bone Growth

- During childhood long bones grow entirely at the epiphyseal plates and all bones grow in thickness by a process called appositional growth.
- 

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The Physiology of Bone Growth (cont)

- The epiphyseal plates have four zones:
 1. **Zone of resting cartilage** which is responsible for anchoring the plate to the epiphysis and is made up of small scattered chondrocytes, which is a mature cartilage cell.

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The Physiology of Bone Growth (cont)

2. **Zone of proliferating cartilage** is responsible for replacing the chondrocytes that die on the *zone of resting cartilage* and it is also made of chondrocytes.
3. **Zone of Hypertrophic cartilage** is made up of chondrocytes that fill in the dead chondrocytes that make up the next zone.

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The Physiology of Bone Growth (cont)

4. **Zone of calcified cartilage** is made up of dead or dying chondrocytes that are held in a calcified matrix which will eventually become bone.

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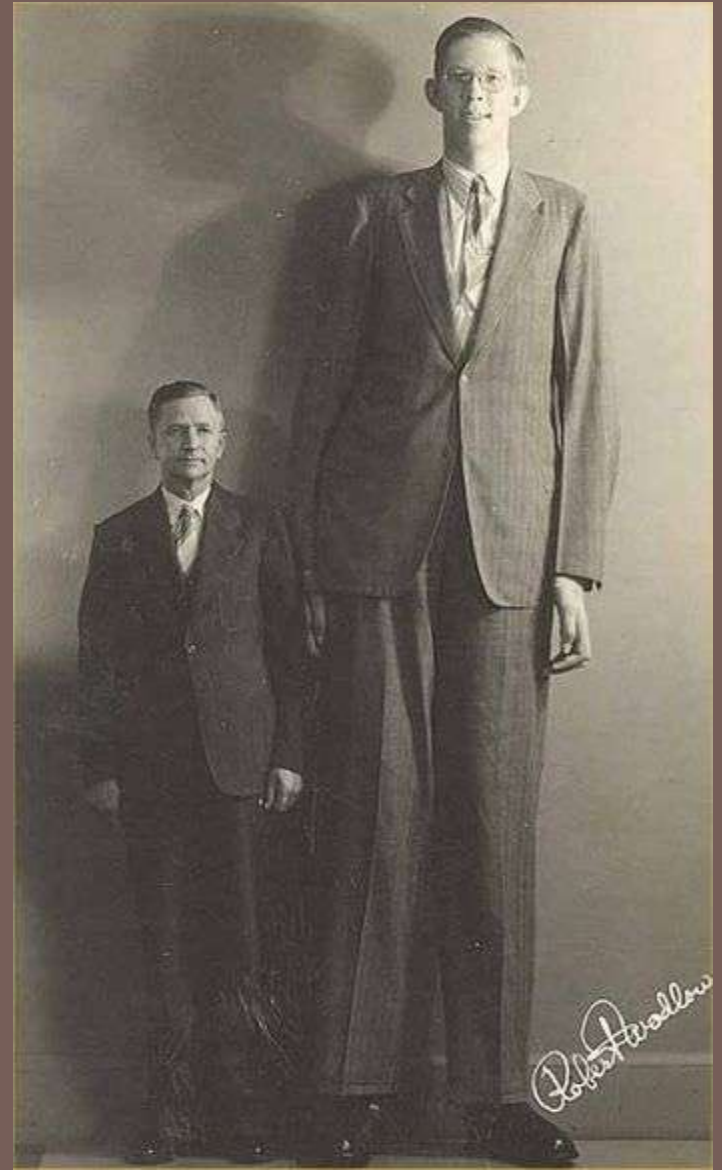
The Physiology of Bone Growth (cont)

- Cartilage cells are created at one end of the plate and they are destroyed and replaced by bone at the other end.
- This means the plate remains almost a constant thickness while growth occurs.

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The Physiology of Bone Growth (cont)

- The rate of human bone growth is controlled by **human Growth Hormone (hGH)** from the pituitary gland and sex hormones from the gonads.



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The Physiology of Bone Growth (cont)

- Ossification of most bones is complete by the age of 25.
- When this occurs the epiphyseal plate is replaced by bone forming the epiphyseal line.

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The Physiology of Bone Growth (cont)

- **Appositional Growth** (growth in girth) occurs in the periosteum, where osteoblasts lay down a matrix of compact bone on the outer surface.

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Bone Remodeling and Repair

- The bones are remodeled and/or rebuilt throughout a persons life.
- The Definition of Headache!
- Much more subtle actions also cause daily wear and tear on bones.

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Bone Remodeling and Repair (cont)

- **Osteoclasts** are large cells that are responsible for bone resorption.
- They use enzymes to solubilize calcium.
- Portions of the femur are broken down and replaced every four months to make sure the bones remain strong.

The Skeletal System

Bone Remodeling and Repair (cont)

- Control of bone remodeling and calcium homeostasis falls to 2 hormones:
 - 1.) **Parathyroid hormone (PTH)**, secreted by the parathyroid when blood calcium levels are low.
 - 2.) **Calcitonin**, secreted by the thyroid and inhibits bone breakdown when blood calcium levels are high.

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Bone Remodeling and Repair (cont)

- Vitamins and minerals are essential for bone remodeling and repair.
- The minerals include calcium, phosphorus, magnesium, manganese and boron.

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Bone Remodeling and Repair (cont)

- The vitamins needed are:
 - **Vitamin D** which increases the absorption of dietary calcium.
 - **Vitamin C** helps maintain bone matrix (deficiency causes scurvy).
 - **Vitamin A and B12** which control the activity of osteoblasts and osteoclasts.